Development of the primary flight display (PFD) recently took a turn into the future. Gone is the painting of mechanical instruments with electric ink. Honeywell has pulled back the curtain on its research, giving professional pilots a close look at what they see as the future. The results may soon become standard for a new breed of vision-based instruments that provide new forms of flight guidance, are simple to use and integrate enhanced vision on the PFD.

Honeywell’s prototypes have now been flying for over a year, and the company has gained the leading-edge experience testing real systems aimed at producing the first of a new generation display for the NextGen environment. The new Honeywell program builds on the latest SmartView product line, and is focused on simplifying instrument flight and on using intuitive visual cues. Preliminary results point to the beginnings of a new kind of head-down flight instrument design applicable for a wide range of aircraft, and could possibly lead to a new operational credit.

Progress on the new flight instrument has come in the midst of the debate in industry on the merits of the synthetic vision system (SVS) versus enhanced flight vision system (EFVS). Honeywell doesn’t see a debate—just a partnership between the 2 technologies that will result in safer flight operations. The company’s recent test flights used an advanced version of the SmartView PFD and the Kollsman EVS II sensor, now integrated as a single display and the first of its kind.

The core of the new SmartView instrument was the first to be certified on large-cabin aircraft, and now is in over 170 Gulfstream business jets. SmartView incorporates a number of innovations in both guidance and terrain information. These include an FAA-approved database that includes 8600 airports worldwide, 30,000 runways and 100,000 obstacles. With over 800 million flight hours of proven EPGWS operations using this database, Honeywell’s capability in the new flight instrument design is almost unfair. The terrain and runway database expertise at Honeywell is unique in the industry, enabling the level of additional detail reliability and precision to be included within the SmartView core instrument design.

Honeywell has also pursued these developments with the collaboration of regulatory groups in FAA and EASA. A key new group formed by FAA—Special Committee 213 (SC 213) for Enhanced and Synthetic Vision—is developing the industry’s minimum standards for this technology, including the safety design aspects required for certification. RTCA SC 213 also includes the partnership of EUROCAE, the European avionics industry group.
that develops aviation standards. Expertise from all these industry and governmental groups is moving at a fast pace to provide the NextGen flightdecks with not only new technology but new approach, landing and takeoff capability.

**Looking at the HUD part**

To get a pilot orientation to the new Honeywell developments, a look at some other displays is needed, and it really starts with head-up displays (HUDs). A new instrument that found its way in airline use first, HUD technology was adopted by the airlines, and then later by several corporate aircraft manufacturers in the mid-90s, including Bombardier, Dassault and Gulfstream.

The innovation of the HUD is the concept of a conformal display with a new form of aircraft control called the flightpath vector (FPV) and flightpath director (FD). Conformal display means that the symbology and imagery match the real world as you look through the transparent display. The combination of the conformal display and the use of the FPV and flightpath reference cue provided a new means to control the aircraft more precisely. FAA agreed that the HUD improved a pilot's accuracy and reduced errors and, in the mid-90s, approved HUDs as a means to fly Cat III approaches manually.

Recently, some manufacturers have begun to incorporate key elements of the HUD into a head-down PFD—in particular the FPV–FD combination. Honeywell’s SmartView includes these basic functions and several other unique design and safety elements, including a registered conformal pitch ladder, scaled runway indicator, extended runway centerline and conformal range rings. The pitch ladder and zero pitch reference line (called the horizon line in non-conformal displays) show the attitude of the aircraft, but the FPV shows where the aircraft is going. Indication of the actual flightpath, as shown by the FPV, is used to control the aircraft more precisely. The FPV and FD provide precision in terms of flight guidance. The acceleration cue is a caret off the left wing of the FPV and allows you to see if the aircraft is in unaccelerated flight, accelerating or decelerating. The speed deviation tape, also off the left wing of the FPV, is referenced to your approach speed. The actual indication is a tape-like symbol that moves up (too fast) and down (too slow) on the left wing of the FPV. The acceleration caret and speed deviation tape are very typical HUD symbology.

SmartView is designed as a PFD, with instrument and flight guidance information integrated with perspective terrain as an additional element of the attitude indicator. The SmartView pitch ladder is expanded and registered conformal, providing improved control of the aircraft on approach. SmartView uses terrain with ground texture and other features as a better and more functional attitude indicator than conventional displays and is a vast improvement in flight safety including reduction of controlled flight into terrain (CFIT). These features give the pilot cues of speed and altitude, much as they would gather when looking out the window at the ground.

**The EVS part**

A problem that has concerned both designers and regulators is how to use EVS technology on a head-down instrument. There are 3 factors to consider—the technology, human factors issues and regulations regarding the design of flight instruments. Honeywell’s research team of human factors scientists and engineers developed a new means to integrate EVS and SVS within the criteria of flight instruments. This includes where to locate the EVS on the display and how to have it contribute to the overall operations. Honeywell also sees the value of EVS as a way to add real-time data to the database of SVS, aid in navigation validation. It could by some accounts lead to an operational benefit.

In essence, the EVS becomes an element of the attitude indicator, but it also provides the visual cues. The use of EVS as a black-and-white-TV-like image provides the visual cues, but looks odd within a PFD as a grayscale image. Honeywell researchers solved that issue with a unique color and texture capability by flexing its graphics and display technology muscle. Now as you fly over the terrain, the EVS image is tinted to match the terrain environment color as shown on the SmartView PFD. The results are pleasing to the eye and this approach also fits within flight instrument regulations.
Honeywell's advanced developments in flight displays integrating SVS and EVS led the company to early flight tests this year. Honeywell has tested the concept in actual low-visibility conditions.

Another issue to be solved was selection of a sensor that could be integrated within the SmartView core display and offer the needed performance. Honeywell and Kollsman have partnered on this effort, conducting flight tests in low visibility to evaluate the new instruments' operation and performance and the use of EVS on an equivalent display as a HUD. Test results have been remarkable for both the technical challenges and new operational benefits, and results for the Kollsman EVS II were what industry has come to expect—the advantage needed to continue in bad weather. But the remarkable thing is that the combination, much to the surprise of diehard HUD fans, works very well.

**Operational credit**

Kollsman's EFVS sensor was the first to be certified for operational credit in 2001 to allow a crew to see the required visual cues at the decision height, and continue on the vision sensor until a 100-ft transition point. The visual transition, which is described in the operational rule FAR 91.175, explains what pilots must see to continue the approach and land. Kollsman EVS II is now standard on most Gulfstream aircraft, and is being retrofitted on the entire fleet of FedEx—the first air carrier to use EFVS for Part 121 operators (FAR 121.651).

Honeywell has conducted flight tests of SmartView with EVS on its Citation Sovereign. The aircraft’s flightdeck has standard Honeywell Primus Epic avionics for the copilot and SmartView installed on the pilot side. The left-most Primus Epic EFIS display has been reconfigured to display either a conventional blue-over-brown PFD image generated by the certified onboard system or the integrated terrain and EVS SmartView images generated by the prototype flight test system. The right side of the cockpit will maintain the certified configuration of 2 Honeywell Primus Epic DU-1080 EFIS display units (PFD and engine display). Testing has included analysis of SmartView design and performance, detailed instrumentation measurements and human factors assessments.

Some other notes about SmartView found in Honeywell's line service and testing are that the design enables a higher degree of performance than a traditional flight director instrument, but accomplished with standard instrument training and with repeatable results. In fact, a significant new level of safety and pilot awareness is achieved with the new instrument. The SmartView advanced display is also designed in accordance with FAA regulations as a primary flight instrument—a key factor when introducing new technology and useful in the end goal of Honeywell for SmartView, which is additional operational credit.

Regulators have laid the foundation for new operational credits for lower approach credit on standard Cat I approaches with new technology. Recently, FAA published Order 8400.13d for operations with a HUD to a 150-ft DH at Cat I facilities in 1400 ft RVR. The idea is that a certified HUD reduces flight technical error and improves pilot performance, enabling an equivalent level of safety at a 150-ft DH. The order states, "Higher performance capabilities of new and improved avionics have mitigated some of the performance requirements of the ground-based navigation equipment.” This also fits within Honeywell's design and development efforts to offer the first of a new generation of flightdeck displays with a capability of 150 ft DH in 1400 ft RVR.

It's one thing to see the potential of the future, and another waiting for the future to happen to your own flightdeck. Once, as we were looking at a piece of so-called new technology in his airplane, a pilot friend of mind remarked, “The future ain't what it used to be.”

I think about this pilot’s view of technology and life often when seeing new machines, and have come to realize that innovation is only part of the story. The other part is how it gets to the cockpit, but the Honeywell folks have kept the challenge of transition in mind. Leveraging the technology of the new SmartView product line, new OEMs or retrofit customers will be getting the benefits of this new flight instrument without the pain of a redo.

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